

INSTRUMENTATION
TECHNOLOGIES



Measurement Campaign with the Libera MONACO 3 System at the VR-1 Reactor Using Two Fission Chamber Types

Val Fišinger
Austin Texas, 22.9.2026

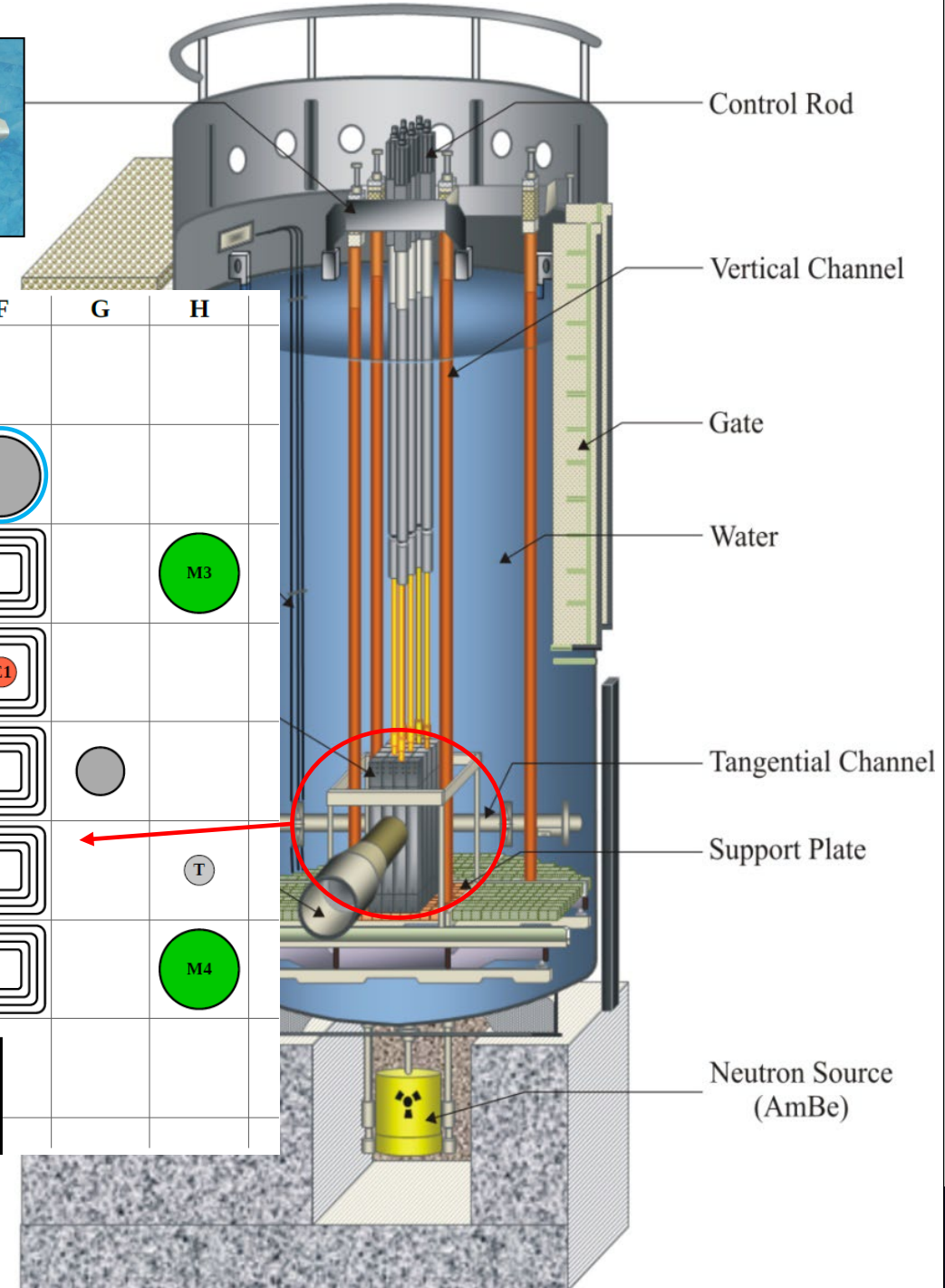
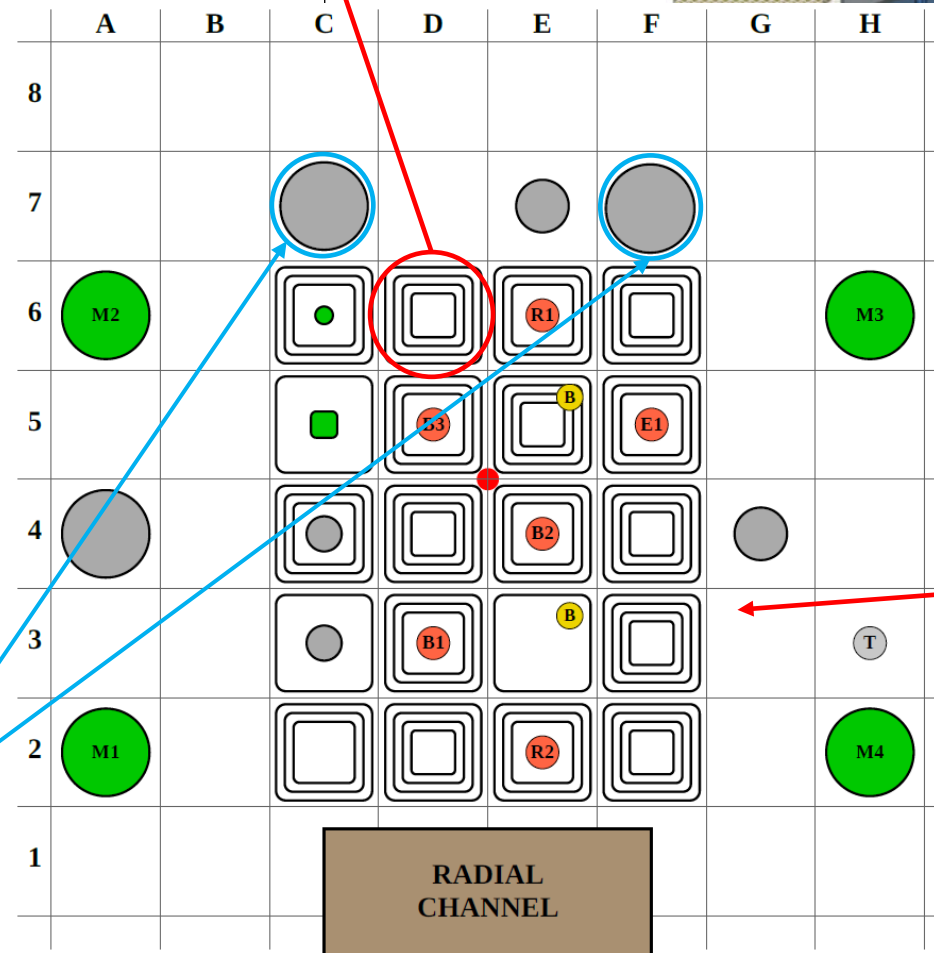
www.i-tech.si

Agenda

- Introduction
- Experimental set up
- Linearity results comparison
- Reactor ramp comparison
- Conclusion

VR-1 Reactor at CTU in Prague

- zero power light-water moderated pool-type reactor with tubular fuel
- fuel assemblies: IRT-4M type (19.7 % of U-235)
- neutron fluxes (fast and thermal) up to $\sim 1 \cdot 10^9 \frac{n}{cm^2 s}$
- Operational power monitoring channels based on RJ-1300 wide range fission chambers switching between Pulse and Campbell modes (positions A2, A6, H2, H6)
- Dry channels for detector tests with Monaco system located at C7 and F7



Detectors

KNK-15 detector

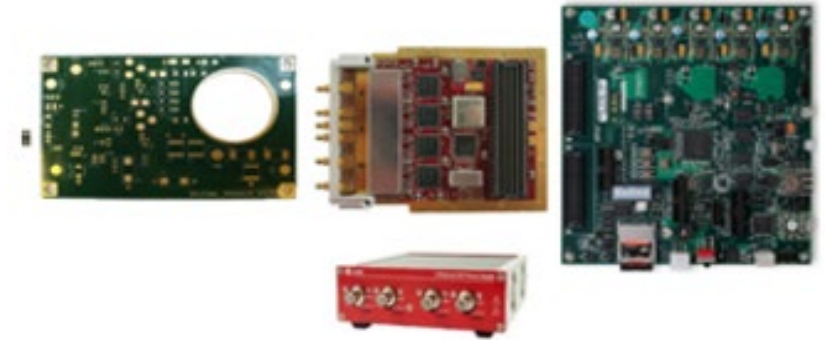
- Compensated Fission chamber detector
- 3 Outputs:
 - Neutron + Gamma signal
 - Gamma signal
 - Compensated neutron signal

RJ-1300 detector

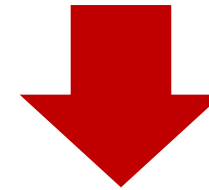
- Guarded Fission chamber detector
- 2 Outputs:
 - Neutron-sensitive signal
 - Guard signal

What is Libera MONACO 3?

- **Libera MONACO 3** is a neutron acquisition system for neutron flux detectors.
- **Has a wide range** of detector compatibility
- Simultaneous acquisition with Pulse mode, Campbell mode and Current mode
- **4 individual** channels available
- Digital Signal Processing with high sampling rate (500 MS/s)



CEA MONACO prototype



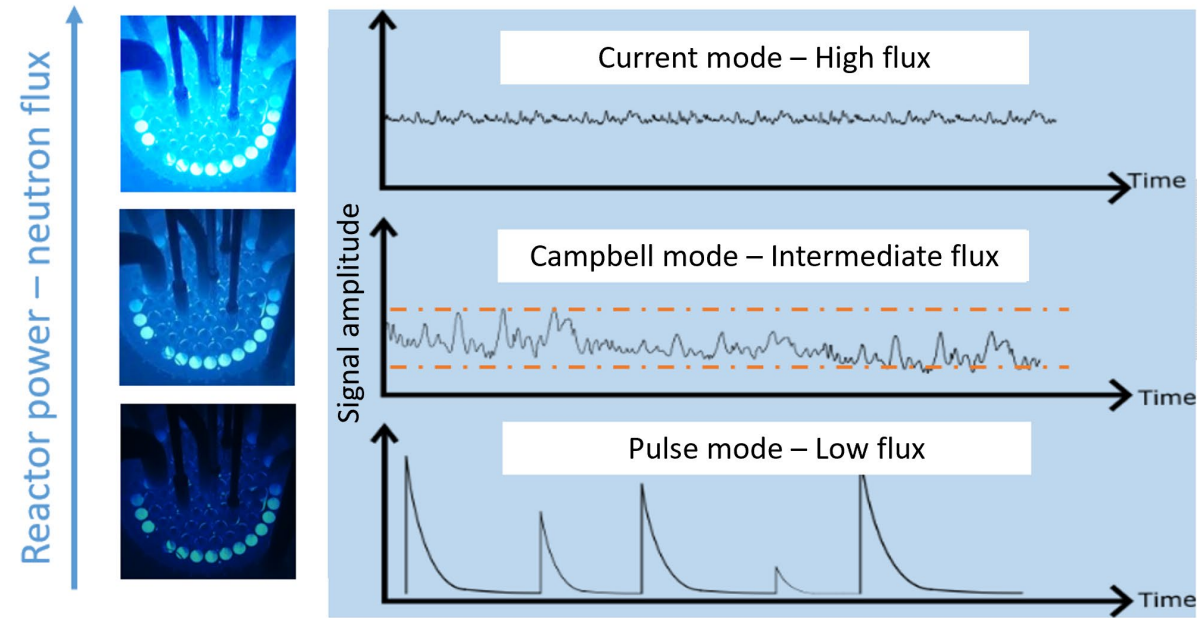
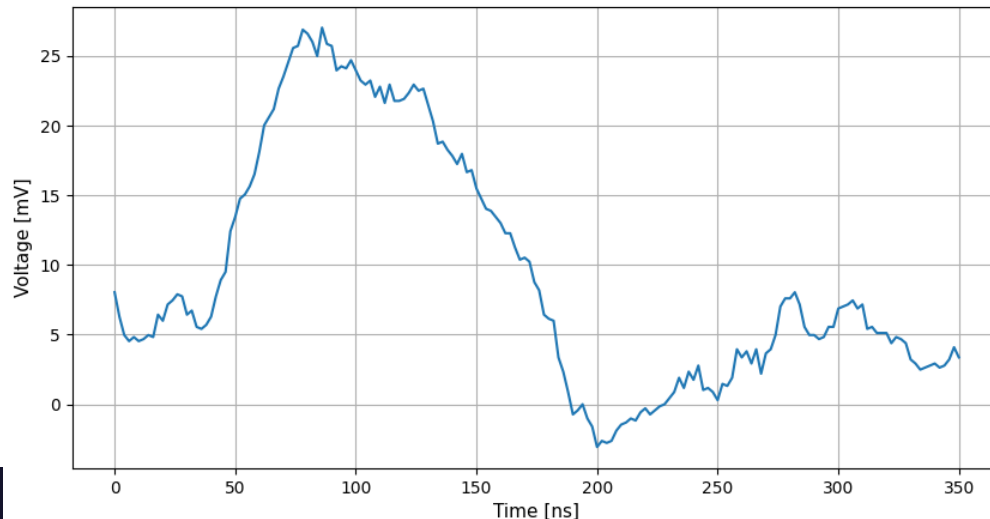
Libera MONACO 3



Why was Libera MONACO 3 chosen for this campaign?

- Capable of characterization of the **whole reactor power range**
- **Pulse mode** for Low neutron flux regimes
- **Campbell and Current modes** for Intermediate to High neutron flux regimes

KNK-15 Pulse

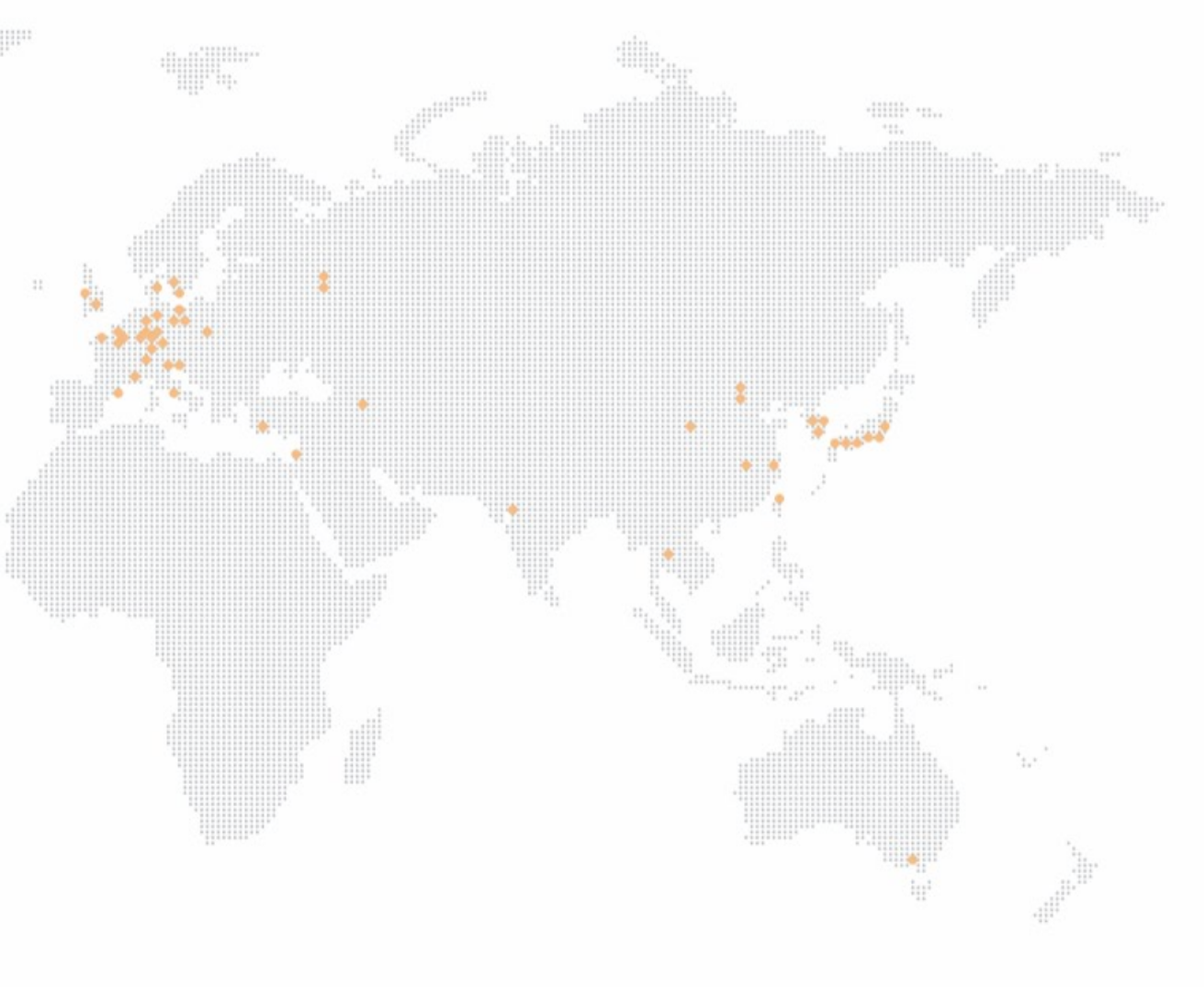


- Allows for easy **pulse visualization**
- Comes with a built in **High Voltage supply** up to **+/- 1kV**



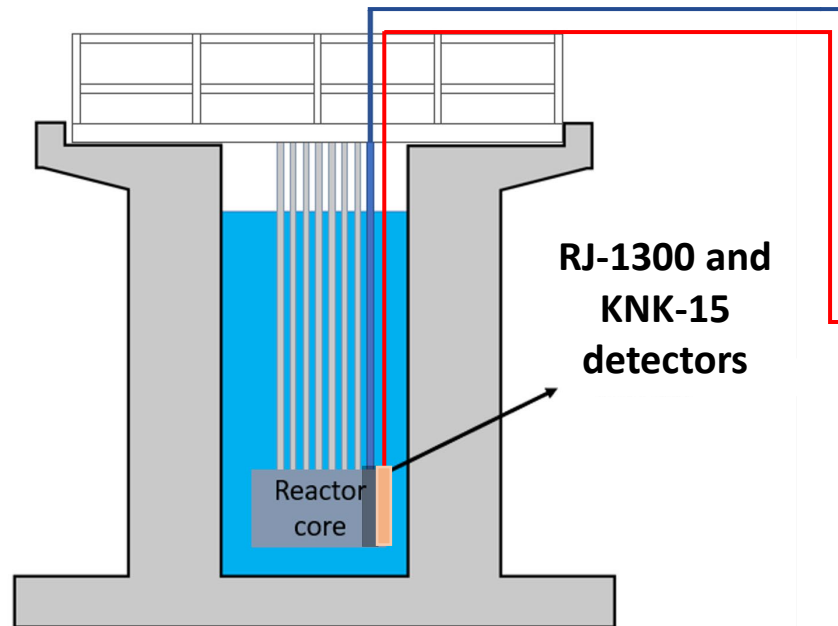
Experimental set up

- Introduction
- **Experimental set up**
- Linearity results comparison
- Reactor ramp comparison
- Conclusion

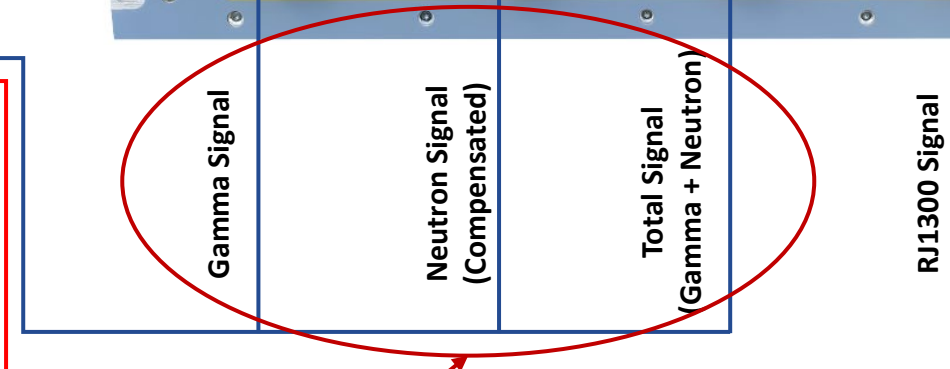


Experimental set up

VR1 Research Reactor



Libera MONACO 3



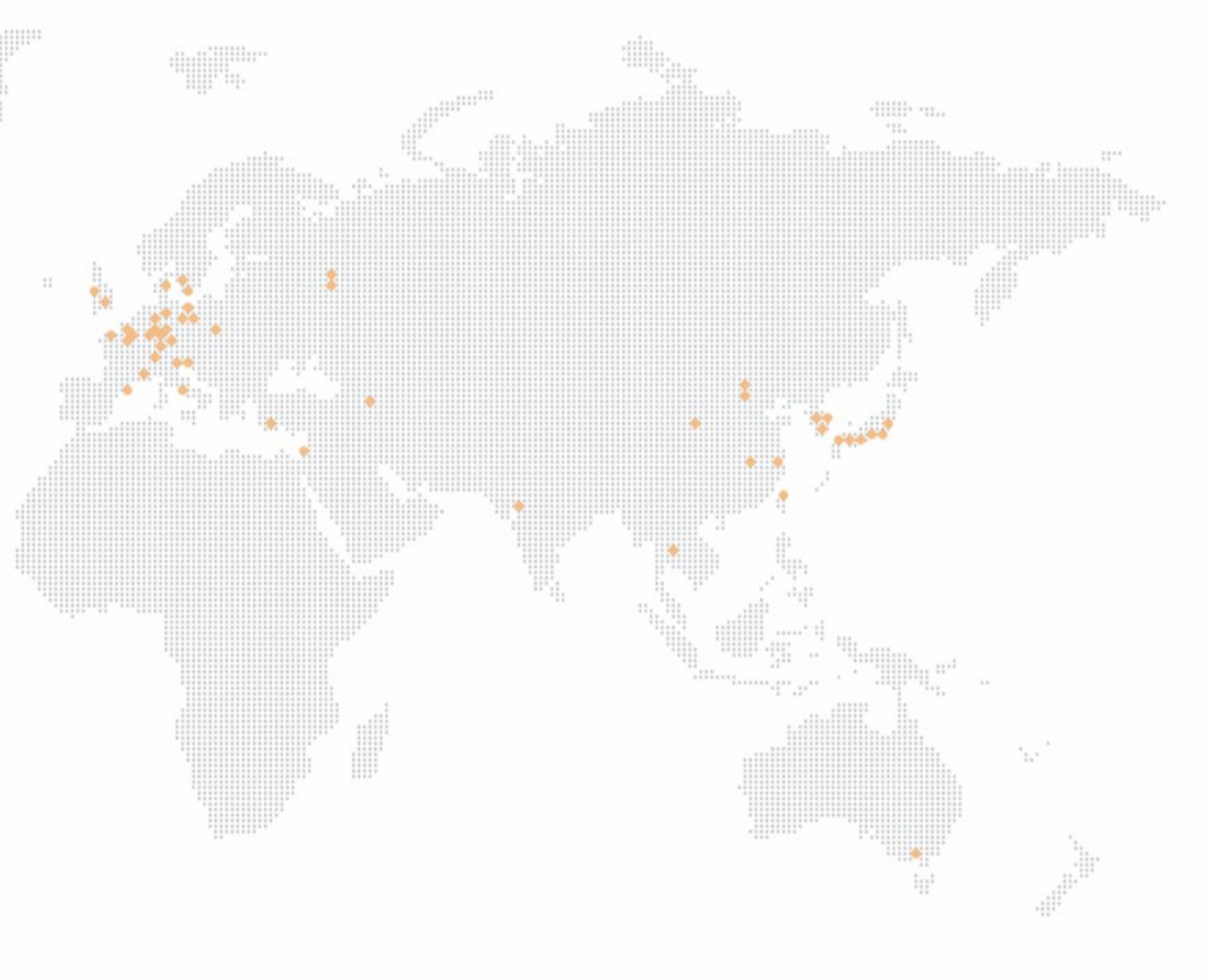
KNK-15 Output signals



INSTRUMENTATION
TECHNOLOGIES

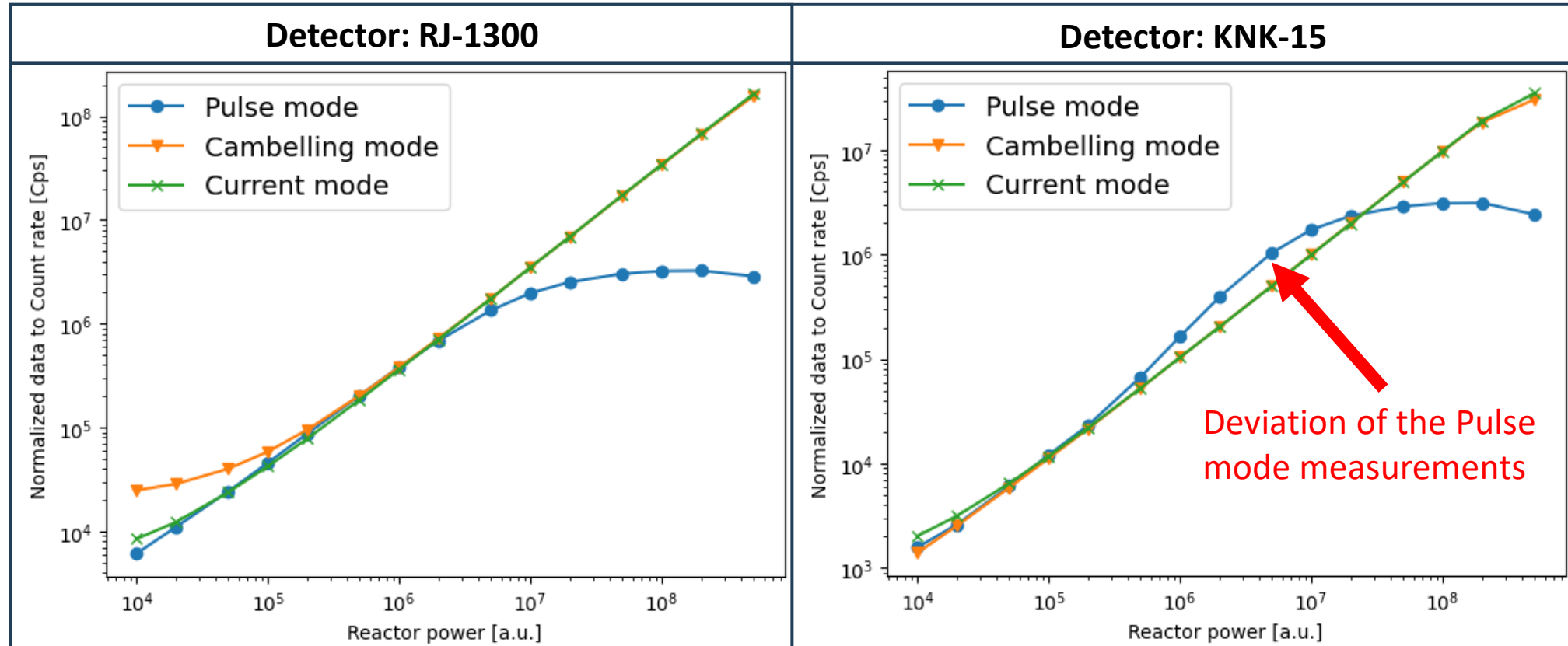
Results

- Introduction
- Experimental set up
- Linearity results comparison
- Reactor ramp comparison
- Conclusion



Measurement conditions:
Power range: $\sim 0\% \rightarrow 100\%$
Number of steps: 15
Detector HV: 500 V

Linearity results comparison



Measurement conditions:

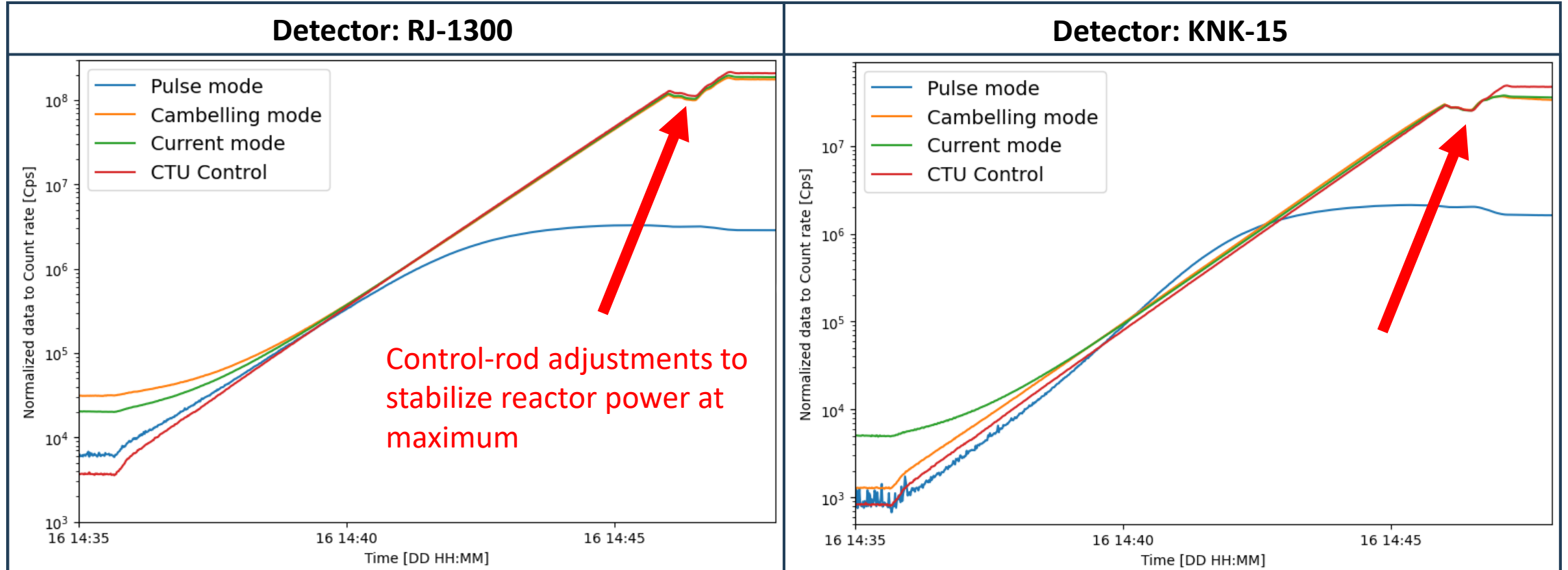
Reactor power: $\sim 0\% \rightarrow 100\%$

Ramp rate: Exponential increase

Reference: **VR1 control system**

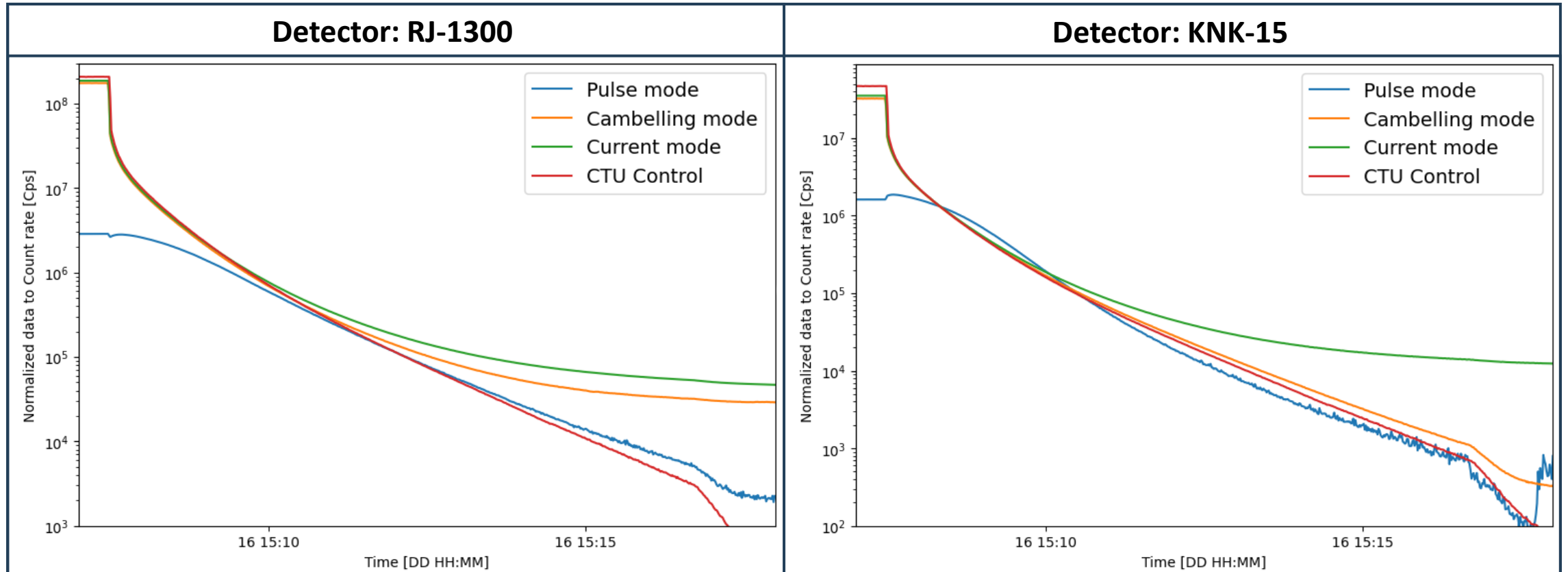
Detector HV: 500 V

Power ramp comparison



Measurement conditions:
Reactor power: 100 % $\rightarrow$ 0 %
Ramp rate: Logarithmic decrease
Reference: **VR1 control system**
Detector HV: 500 V

Power fall comparison



Conclusion

- Linearity measurements confirmed Libera MONACO 3 **compatibility with:**
 - **RJ-1300** guarded fission chamber,
 - **KNK-15** compensated fission chambers.
- Power-ramp measurements demonstrated Libera MONACO 3 **capability** of tracking the full activity of the **VR-1** with **both** detector, with results comparable to CTU's standard control-system output.
- Libera MONACO 3 revealed a deviation in the Pulse-mode response of the KNK-15 detector compared with Campbell and Current modes, which was not observed with CTU's existing instrumentation.



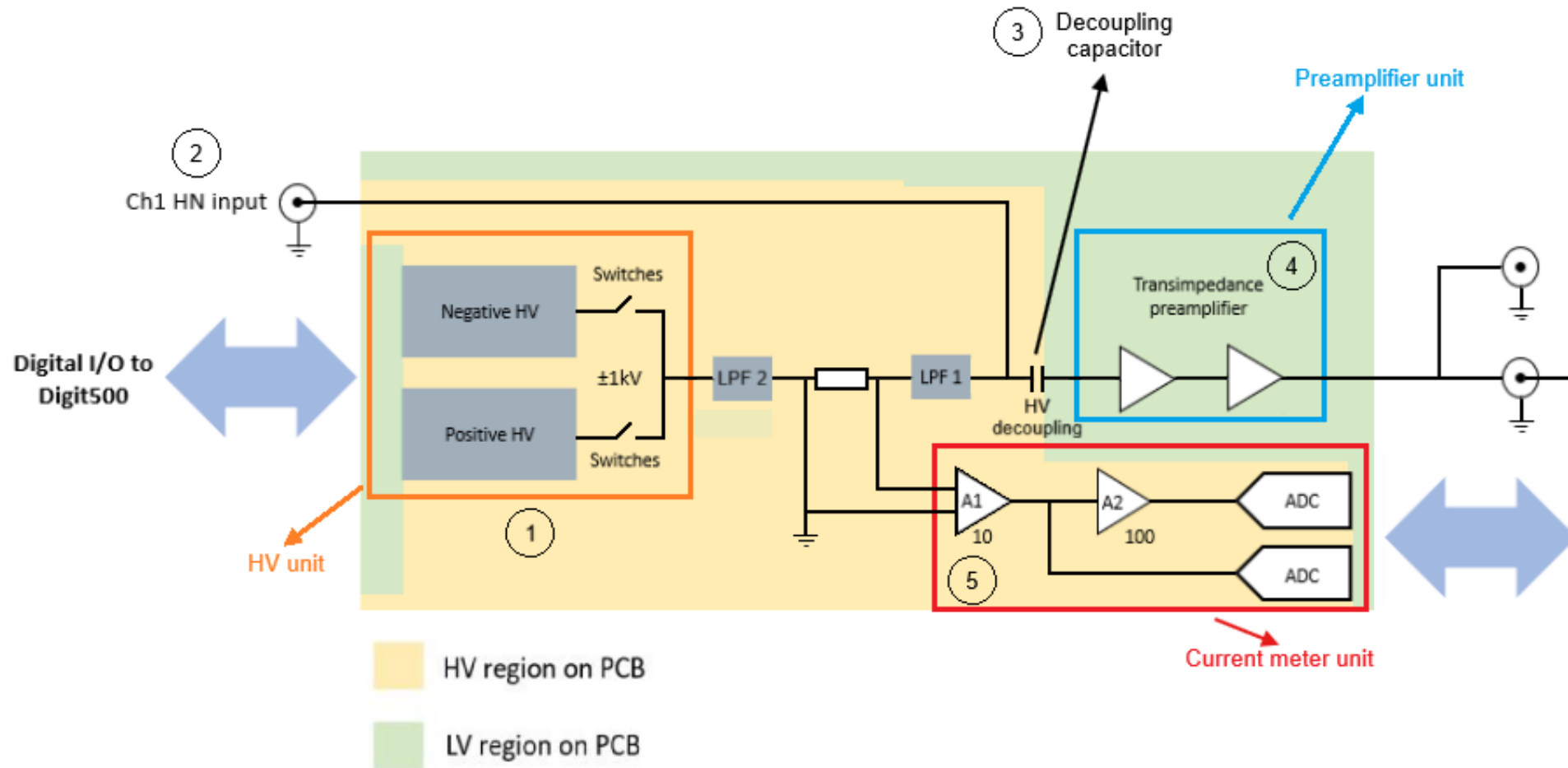
Extra slides



Specifications

Use	Multichannel real-time data acquisition system for neutron flux measurement of neutron sources and research nuclear reactors	
Number of channels	4	
Acquisition electronics	Sampling rate	500 MS/s
	Resolution	14-bit
	Dynamic range	90 dB
	SoC	Zynq 7035
Bandwidth of the transimpedance amplifier	> 20 MHz which allows retrieving current pulses up to 10 μ A of amplitude	
High Voltage polarization output	Up to 1 kV for each independent channel	
Reactor power range	Three measurement modes from zero power to maximum power using	
	Counting mode	from a few Cps to 10^7 Cps
	Campbell mode	Intermediate ranges
	Current mode	Up to 1 mA with 1 nA resolution at lower ranges
Neutron flux range	Up to $10^{15} \text{ ncm}^{-2} \text{ s}^{-1}$	
Digital Signal Processing modules	Oscilloscope mode for pulse visualization	
	Pulse Height Analysis	
	Automatic detector operating curves	
	Online statistics and data acquisition	
Dimensions	Rack-mountable: 19" wide, 3U high	
Power Supply	220 V	

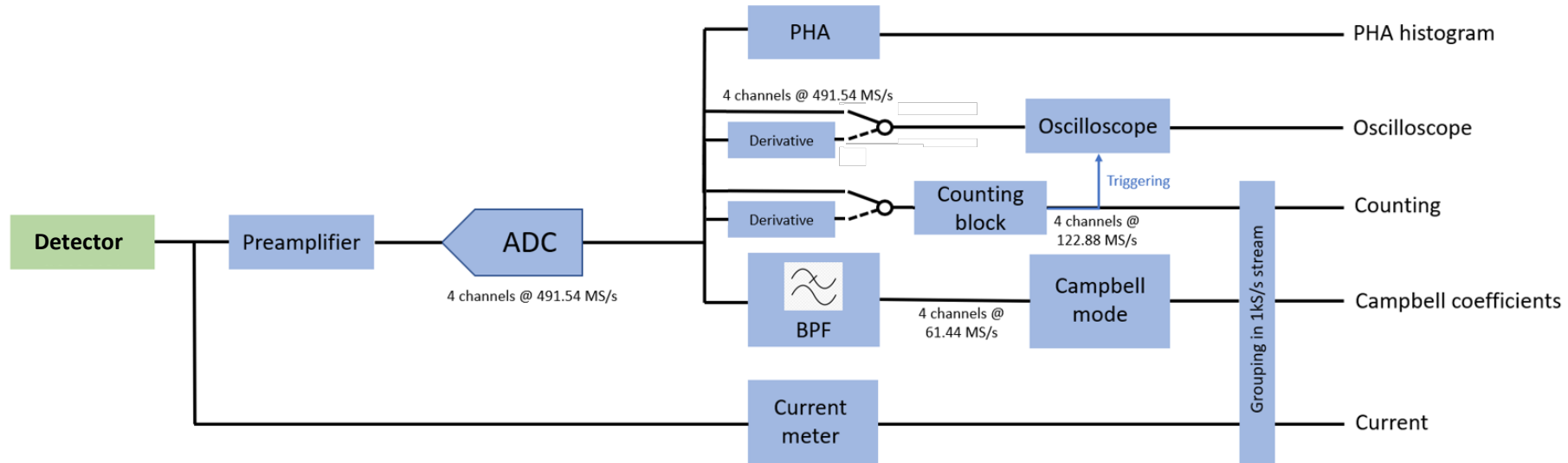
Hardware and frontend



Libera Digit 500

- Zynq 7035 SoC (ARM + FPGA)
- Sampling: 500 MS/s, 14 bit resolution
- BW: 0-250 MHz
- Dynamic range ~ 90 dB

Digital Signal Processing



The DSP block integrates different sub-blocks with different functions:

- **Oscilloscope:** allows the user to visualize and retrieve the pulse data in mV both in raw or differentiated format.
- **Counting mode block:** this DSP block performs a constant computation of the number of pulses and exposes the count rate of the system to the Monaco stream. It has two different algorithms for pulse calculation (chosen by the user)
- **Campbell mode block:** This DSP block calculates the K2-4 coefficients
- **PHA histogram:** Pulse Height Analysis, calculates the charge associated with the pulses and provides these data in a buffer that can be a plot by the user
- **Current meter:** measures the current in the range of 0-1 mA.

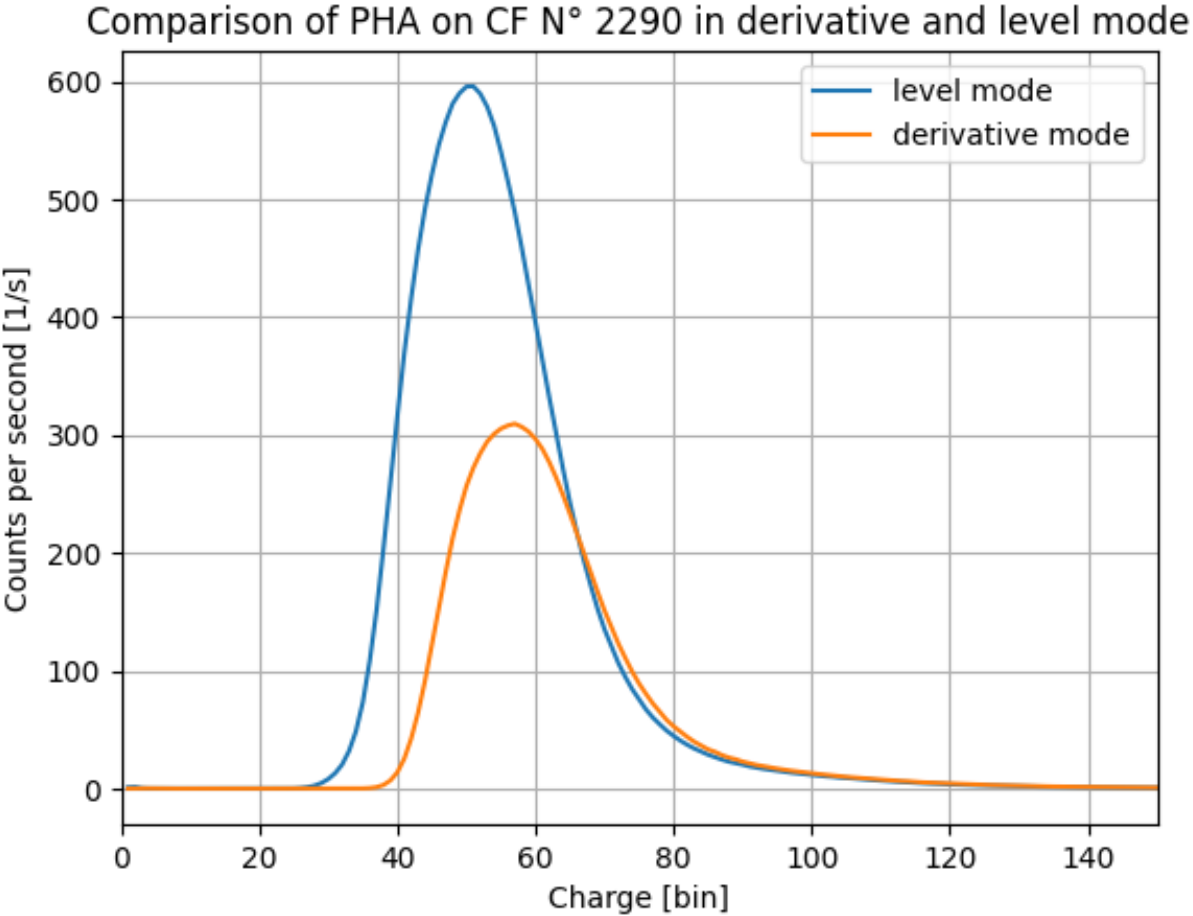
Confirmed compatible detectors

Manufacturer	Name of the cell	Type of the cell	Reactive material	Tested with high gain
CEA	FC2123 Th	Fission chamber	Th232	No
CEA	DER/SPEX CF N° 2260, DER/SPEX CF N° 2290, DER/SPEX CF N° 2315	Fission chamber	U235, Np237	No
Cividec	CVD detector with Lithium converter	Diamond detector	Diamond	Outside amplifier needed
Exosens	CFUC16	Guarded FC	U235	No
Exosens	CFUD111, *	Fission chamber	U235	No
Exosens	CPNB44, CPNB64	Proportional counter	B-10	No
ILL	N° MM96-03-1D, N° MM150-003, N° MM250-01	He3 detector	He3	Yes
ILL	U 1003, U 285, U 769	Fission chamber	U235	No
QST	SiC detector	SiC detector	SiC	Yes
Skoda	RJ1300	Guarded FC	U235	Yes
SNIIP	KNK-15	Compensated FC	U235	Yes

* CFUE22, CFUE24, CFUE32, CFUF34, CFUF44, CFUG08, CFUL08, CFUL600, CFUL64, CFUL64

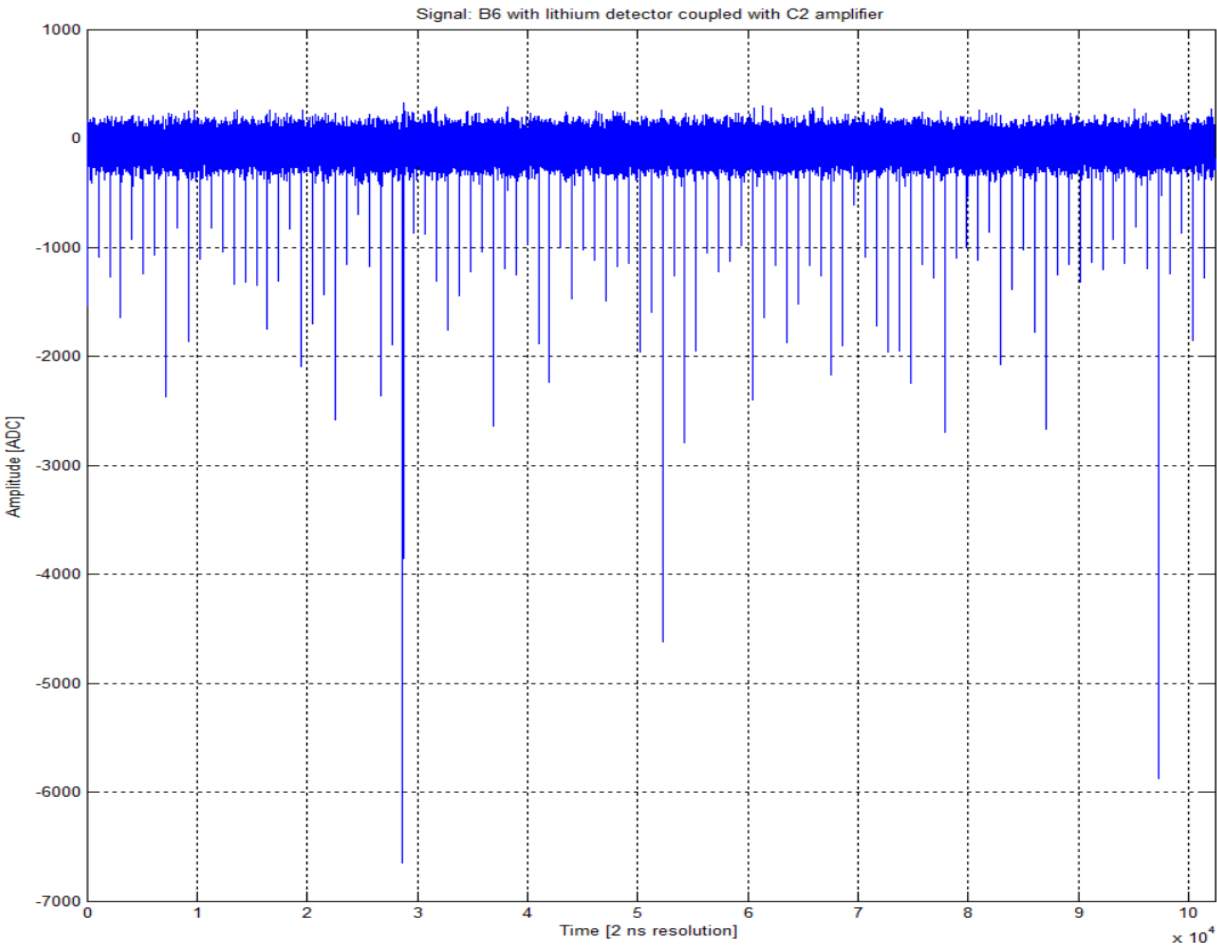
Results:

Detector	Source	Instruments used
DER/SPEX CF N° 2290 (FC)	IJS reactor	MONACO 3



Results:

Detector	Source	Instruments used
CVD detector with Lithium converter (Diamond detector)	Neutron source	Extra amplifier needed, MONACO 3



Results:

Detector	Source	Instruments used
2x SiC detectors, FC 165	IJS reactor	MONACO 3

